Post-Stroke Prognosis on the Basis of Learning Performance

Donald A. Bakal & Linda E. Weaver

A Final Report Submitted to the

Senior Citizens Secretariat

ABSTRACT

Performance of stroke patients on computer-assisted learning tasks was documented at 3 to 5 weeks post-stroke. Early learning performance was found to be strongly predictive of progress made in treatment and level of independence achieved by 6 months post-stroke. The predictive power of learning was maintained while controlling for the variance associated with neuropsychological test performance, age, gender and education. These preliminary data suggest that the learning performance of stroke patients may reflect a general capacity for cognitive-behavioral change, which is essential to the rehabilitation process.

Cognitive dysfunction after stroke is now accepted as an important limiting factor in rehabilitation. Disturbed performance in several areas, including visuospatial and perceptive abilities, memory function, motor persistence, and praxis, has been correlated with a failure to reacquire self-care skills. The significant relationship of several individual tests to poor rehabilitation outcome implies that the dsiruptive factor is one of severity of impairment rather than any one type of deficit. Concomitant with the focal deficits after cerebral injury are a reduced capacity for organization, a lowered level of abstraction, a loss of interest and spontaneous motivation, and a slowing of learning.

Individual differences in physiological aging coupled with wide variation in the nature of focal deficits and severity of stroke, leads to considerable heterogeneity in terms of functional capability and potential for rehabilitation and recovery after stroke. To date, investigators concerned with prognosis after stroke have based cognitive assessment on diagnostic tests and the documentation of deficits, rather than investigating directly the potential for learning. This has occured despite the underlying premise that psychological test results would be directly related to functional competence necessary for retraining in self-care activities. The power of prediction obtained in the available studies has been criticized as being too weak to be clinically useful and there have been recent calls to expand the focus of neuropsychology from pure diagnosis on the basis of static tests to the broader areas of concern for rehabilitation. We have undertaken to examine directly the potential for learning after stroke and the prognostic utility of an early assessment of learning performance as it

relates to progress in treatment and outcome 6 months post-stroke. The following constitutes some of our preliminary findings.

SUBJECTS AND METHODS

The subjects were 25 patients (12 males, 13 females) in acute care, between 50 and 87 years of age ($\underline{x}$ = 69.80; s.d. = 8.855), who had suffered stroke less than 3 weeks prior to our initial contact. The subjects ranged 2-15 years in education ($\underline{x}$ = 9.84). On the basis of neurological and neuroradiological consultation, it was determined that 13 patients had documented (CT scan) evidence for the presence of relatively large superficial infarcts involving cortical and subcortical white matter. The remaining 12 were thought to have had strokes due to small infarcts or hemmorrhages involving the deep white matter (internal capsule), thalamus or basal ganglia. Eighteen of the 25 patients were classified as having left hemisphere stroke. Formal consent was obtained from each patient in the presence of family. A group of control subjects (n = 15) of similar age (x = 69.38; s.d. = 7.433) was obtained from spouses/family members of participating patients and from community volunteers.

At one month post-stroke, patients were administered tests to assess learning and other cognitive functions. Learning performance was measured across a series of five computer-assisted learning tasks, designed so as to encourage optimal performance among elderly learners. The tasks were designed specifically for this project, on the basis of published literature concerning educational techniques and considerations for older and brain-injured people. The tasks

incorporate a variety of cognitive demands, and include: a perceptual learning task (picture completion); a visuospatial (map) learning task; a verbal discourse (story) learning task; a problem-solving task, which requires learning by trial and error; and, a pattern construction task, which utilizes and allows comparison between 3 different instructional modes (verbal, demonstration, both together).

Neuropsychological tests included those for perceptual (tactile) integration; visuospatial neglect; span of attention; language comprehension; rate of language production; vocabulary; verbal memory; nonverbal memory; visuo-constructional ability; abstract reasoning; and, depression.

To accomodate the limited stamina of the elderly stroke patients, the assessment was administered a few tests at a time, a duration of approximately one hour or less per session. The computerized learning tasks together required approximately 30 minutes to complete. The tasks are not paced thereby allowing each patient to proceed at his/her own speed. Although the time required to do each task varied, no patient was allowed to continue in a task indefinitely. In the event of failure, the computer rerouted the patient to a simpler version and the completion statement.

At 6 months post-stroke, two rehabilitation professionals rated patients as to the degree of recovery seen in physio-, occupational, and/or speech therapy, and the maximum level of self-care and independent living skills achieved. The ratings were made by an occupational therapist of 14 years experience and a speech pathologist with 10 years experience in a rehabilitation setting. They were blind to the results of the learning and neuropsychological assessment.

The degree of recovery seen in treatment was rated on the basis of ambulation, transfers, communication and activities of daily living, and reflected overall change in functional status. Degree of recovery ranged from little or slow progress to strong gains or full recovery. Independence ratings were made on the basis of level of self-care and communication skills; with four possible categories of group placement:

(1) completely independent in self-care and activities of daily living, or largely independent with some community support such as weekly visits by the community health nurse.

(2) discharged from hospital and rehabilitation treatment and living in a private home but receiving daily mild to moderate assistance from live-in family and/or daily community support.

(3) still activiely engaged in rehabilitation treatment at 6 months post-stroke, either as an inpatient or outpatient. It does not include those awaiting placement in long term care facility.

(4) dependent in several areas of self-care and placed or awaiting placement in nursing home, auxilliary hospital, or requiring family assistance with most activities of daily living.

The raters agreed with one other prior to conferring in 90% (19/21) of the cases for which progress in treatment was rated and in 77% (17/22) of the cases for which independence was rated. Discussion to reach consensus resulted in 100% agreement. Four of the 25 stroke patients did not receive treatment by hospital rehabilitation staff. Three patients were lost to followup such that we were unable to determine level of independence achieved by 6 months post-stroke.

RESULTS

Performance in each learning task was measured in terms of trials to criterion. Subjects varied considerably in whether or not they were able to reach criterion in the number of trials alotted. A learning achievement ratio score was derived to reflect a subject's learning performance across the four tasks. The score reflected the proportion of tasks in which criterion was achieved and was calculated on the basis of the tasks in which the subject was able to participate. This method of scoring compensated for patients with response limitations that prevented participating in all the tasks (for example, aphasia prevented subjects from responding in the picture recognition and story learning tasks). The method of scoring permitted learning achievement to be examined for subjects who would have otherwise been eliminated in statistical analysis because of missing data.

The mean learning achievement ratio score for the normals was .88, with the majority of subjects (14/16) obtaining a ratio greater than .70. The patient group exhibited a mean overall achievement ratio score of .60 with 15 of 22 obtaining a ratio score greater than .70.

The raters categorized 11 patients as having made good progress in rehabilitation and 10 patients as having made little or no progress in rehabilitation at 6 months post-stroke. Discriminant function analysis was used to determine the percentage of patients correctly classified on the basis of learning performance at 3 to 5 weeks post-stroke. Eighty-six per cent of the stroke patient sample was correctly classified as to whether good or relatively slow progress was made (Table 1). In order to examine the relative contributions of the cognitive and medical variables to progress in treatment, the latter variable was regressed on the learning, neuropsychological and

radiological data. Age, gender and education were also allowed to compete for entry with the other variables. The learning achievement score, reflecting the percentage of tasks successfully learned to criterion, was identified as the strongest predictor of progress among the variables investigated. The neuropsychological test scores were found to be very weakly related to progress in treatment. Only tactile integration was selected by the stepwise logistic program for entry into the predictive equation (with coefficient = -0.398 and Improvement Chi Square = 5.984; $p < .05$), and it was eliminated statistically when forced to compete with the learning achievement score. The latter was found to make the strongest contribution to the prediction of treatment progress (with coefficient = -7.74 and Improvement Chi Square = 7.132; $p < .01$).

The early assessment measures were also investigated regarding their ability to predict ultimate independence. The basis for rating independence was on self care and independent living skills, rather than handicap in employment or place of discharge. This was considered appropriate because most of the patients were retired and some who returned home required constant care by family members. Four groups were created, described as: 1) those patients independent in ADL, and living in own home with minimal community support (n = 13); 2) those discharged from treatment who live in own or family home but receive daily mild to moderate assistance from live-in family or daily community support for meals, housekeeping, or nursing needs (n = 3); 3) those still actively engaged in rehabilitation treatment, either as in-patients or out-patients, but excluding those awaiting definite auxilliary hospital or nursing home placement (n = 3); and, 4) those

who are dependent in several areas of ADL, and who have been placed or are awaiting placement in nursing home or auxilliary hospital, or discharged to a family member's home, where they would be dependent on others for several aspects of ADL (n = 3). On the basis of a discriminant function analysis, 82 per cent of patients were correctly classified as to their level of independence on the basis of their learning performance at 1 month post-stroke. As with progress in treatment, the learning achievement score was a strong predictor of future level of independence (with coefficient = -3.487 and calculated $F_{[1,20]} = 22.625$, $p < .01$). Furthermore, when the variance associated with the neuropsychological test scores and demographic variables (age, sex, education) was controlled, the learning score continued to make a significant contribution to the predictive equation (with coefficient = -3.854 and calculated $F_{[1,11]} = 10.43$, $p < .01$). The reverse was not found to be the case.

SUMMARY

The results of the present study, although preliminary, suggest that learning performance represents a useful approach to the assessment of post-stroke prognosis. The analyses demonstrated that learning achievement is unique in its contribution to prediction of treatment progress and future levels of independence, reflecting something more than the severity of impairment measured in standard neuropsychological tests. Successful retraining and recovery after brain injury are thought to occur on the basis of restoration of function within an

injured but not completely destroyed neurological structure, and/or reorganization of behaviour patterns to an altered form. The ability of the CNS to undergo structural and functional reorganization is termed "neuroplasticity", and there is evidence to suggest that neuroplastic processes are present even in advanced age unless pathological processes have interfered. Learning performance has been identified as a behavioural marker of plasticity in neurobehavioural studies, being highly correlated with synaptic efficacy and synaptic morphology. Thus, recovery after stroke as it may involve reparation and relearning processes, can be expected to be influenced by individual differences in neuroplasticity and learning capabilities.

Regardless of its final neurological origins, it appears that learning performance has considerable potential to guide post-stroke prognosis and management decisions. In a remedial program, the bulk of effort is directed towards making the most of a patient's abilities to adapt to his injury. Beyond having to master ambulation or transfer chair-to-chair, the patient returning to independent living will be required to prevent or avoid problems presented by post-stroke changes in physical or communicative capabilities. He/she will have to adapt the environment to his/her needs, and compensate for areas of loss by actively employing alternative behavioural strategies. Such adaptations require the ability to actively undergo behavioural change. In questions of prognosis, a broadly based assessment of learning abilities may provide a practical means of documenting neuroplasticity as well as overall severity of the focal deficits suffered by stroke patients.

ACKNOWELDGEMENT

We express our appreciation to the Senior Citizens Secretariat for providing initial funding of this research. Publications of the research will acknowledge the Secretariat's support.